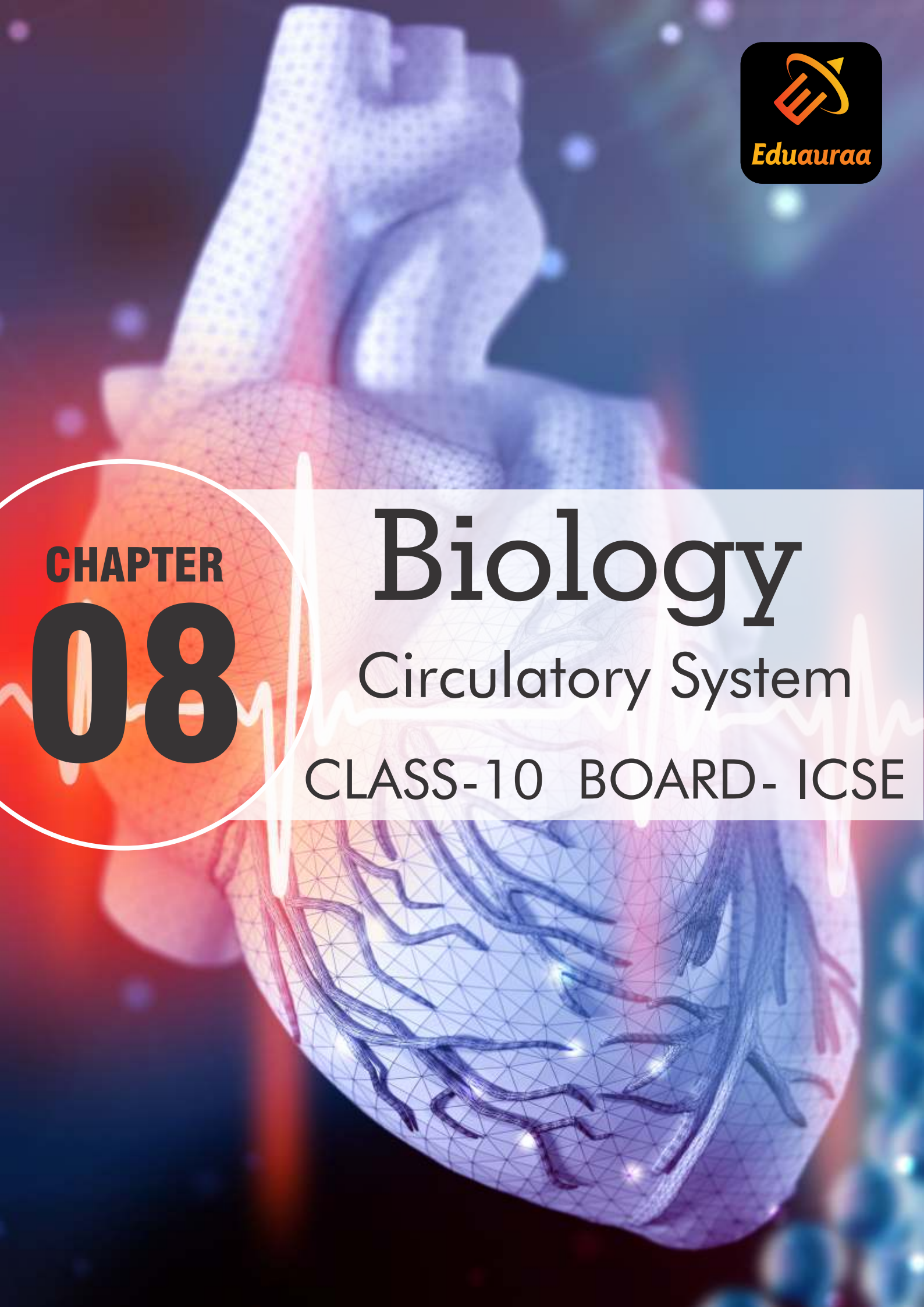

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CHAPTER

08

Biology

Circulatory System

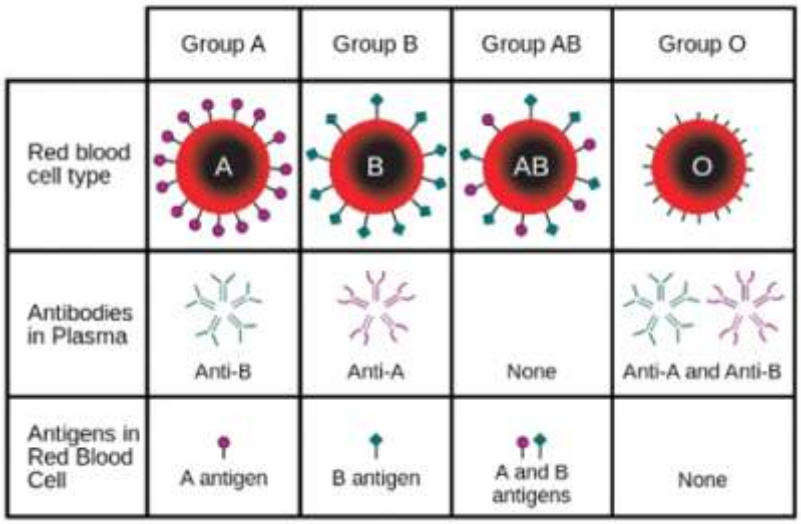
CLASS-10 BOARD- ICSE

Index

Circulatory System

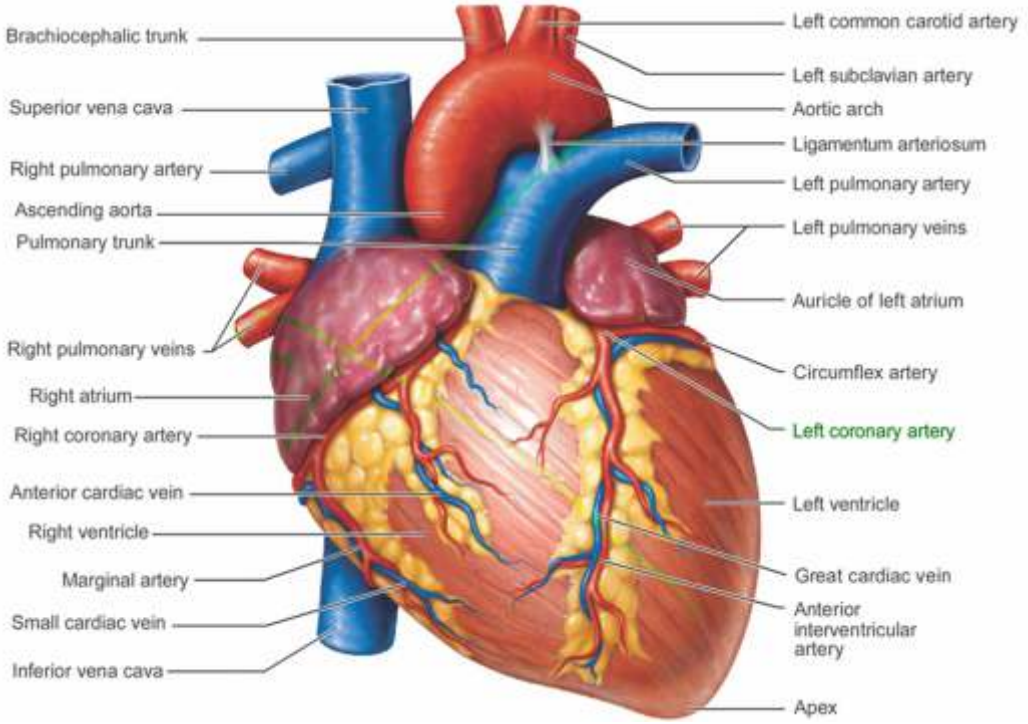
Learning Objectives

- To study the composition and functions of bloods.
- To learn about the process of blood clotting.
- To understand the blood grouping systems and their use in blood transfusions.
- To study about the different blood vessels.
- To learn about the structure and function of heart.
- To understand how blood circulation takes place in body.
- To learn about the lymphatic system



Important Terms

- Blood is the primary circulating fluid of our body.
- Plasma without fibrinogen is called as Serum.
- The cellular components of blood, also known as formed elements, are – Red blood cells (erythrocytes), White blood cells (leucocytes) and Platelets (thrombocytes).
- Clotting or Coagulation of blood is the process in which a clot is formed at the site of injury.
- Blood vessels in our body are of three types – Arteries, Veins and Capillaries.
- The Circulatory system comprises of heart and blood vessels
- The heart is divided into four chambers – two upper chambers called atria or auricles and two lower chambers called ventricles.
- One cardiac cycle (contraction and relaxation of auricles and ventricles) is known as one heart beat.
- Sino-atrial node (SAN) helps in regulating the heart rate and is therefore called as Pacemaker of heart.
- Lymph is the part of tissue fluid that is not reabsorbed in the blood vessels.



Front View Of Human Heart

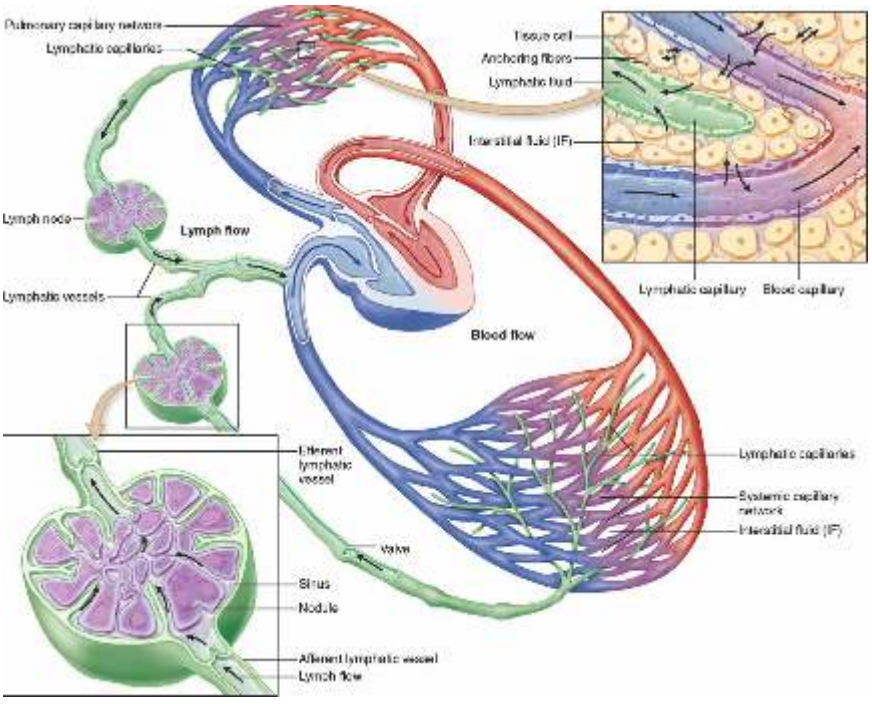
8.0 Introduction

In the bodies of most living organisms, there are circulating fluids present. These fluids form a system with the help of which substances are supplied and collected to and from various parts of the body. In this chapter, we will learn about the circulating system of our body and its function.
There are many examples showing connection of different organs with the circulation system. This indicated the importance of circulating fluids in our body. Let us look at some of the examples.
The food that we ingest is digested by the digestive system. The nutrients obtained during the process of digestion are transported to all the other parts of the body with the help of circulatory system.
In the process of respiration, the oxygen received from the air is transported to all parts of body by the circulatory system. Also, the carbon dioxide from all parts of body is collected by the circulatory system and carried to the lungs.
Endocrine glands are ductless glands. The secretions of these glands (hormones) are carried by the circulatory system.

Circulatory fluids in human body

Blood, Lymph and Tissue fluid are the principal fluids of our body.
- Blood – It is present in heart and blood vessels.
- Lymph – It is found in lymph vessels and lymphatic organs.
- Tissue Fluid – It occupies the empty spaces between cells in organs.

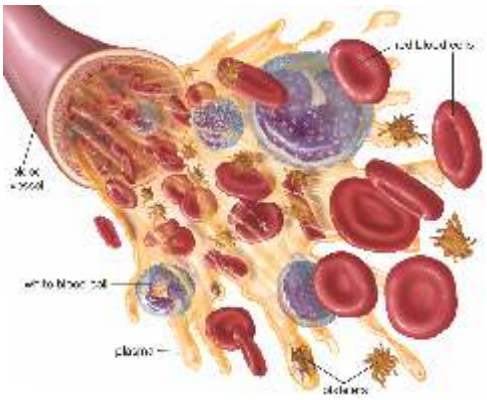
The connection between these three fluids can be observed in the following figure. In the figure, we can see that blood circulates within tubular structures known as blood vessels. So, in our body, blood circulates in a closed blood circulatory system. In bodies of certain organisms, for example insects, blood flows openly in the spaces in body, without blood vessels. This is known as open blood circulatory system.



Representation Of Blood And Lymphatic Circulation

8.1 Blood

Blood is the primary circulating fluid of our body. It has many functions other than transport of materials. Blood is a fluid connective tissue formed of many elements combined together. Let us learn about the various properties and functions of blood.



8.1.1 Properties

- Blood is a thick fluid. The oxygen rich blood has bright red color whereas the carbon dioxide rich blood has dark red color.
- Blood never remains stationary. It is always flowing from heart to blood vessels and back.
- An average adult human has 5-6 liters of blood in their body.
- Blood has pH of 7.3 to 7.45 hence it is slightly alkaline in nature and tastes saltish.

8.1.2 Functions

The functions of blood can be broadly divided into two categories –
1. Transport
2. Protection.

Transport

- Blood transports nutrients obtained from digested food from alimentary canal to all the other parts of body. The nutrients include glucose, vitamins, amino acids minerals, etc.
- Blood transports oxygen from lungs to tissues. In blood, red blood cells are present. These cells contain hemoglobin. Oxygen from lungs form an unstable compound with hemoglobin called oxyhemoglobin which breaks on reaching tissues to deliver oxygen.

  $Hb + O_2 \rightleftharpoons Hb.O_2$ (Oxyhemoglobin)
- Blood collects carbon dioxide molecules from tissues and transports them to lungs. Some carbon dioxide molecules combine with hemoglobin while others remain in blood plasma.

  $Hb + CO_2 \rightleftharpoons Hb.CO_2$ (Carbaminohemoglobin)
- Blood collects excretory materials from various tissues and transports them to liver, kidney and skin for elimination.
- Endocrine glands secrete hormones which are transported and distributed with the help of blood.
- Blood helps in maintaining uniform body temperature by distributing heat evenly in body.

Protection

- A clot is formed by the blood components wherever there is a cut. This clot prevents further loss of blood and also prevents entry of micro-organisms.
- To prevent the body from harmful bacteria that have entered the body, white blood cells engulf these bacteria and thus eliminate them.
- There are particular blood cells that produce antitoxins and antibodies to nullify the effect of toxic substances and to kill the germs that enter the body.

8.2 Blood – Composition

On the basis of composition, blood can be divided into two parts – Plasma and Cellular components.

- Plasma – It constitutes 55-60% of blood. It is the fluid part of blood.
- Cellular components – It constitutes 40-45% of blood. It includes red blood cells, white cells and platelets.

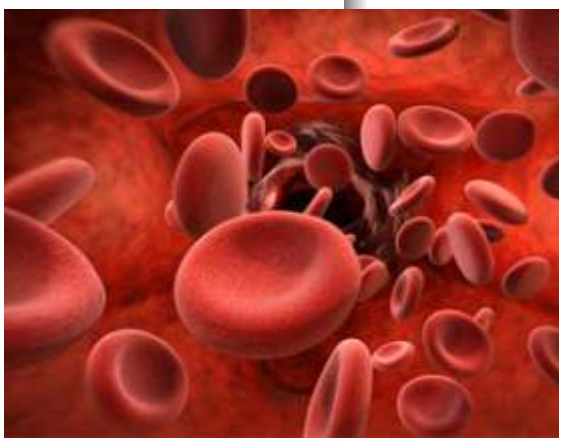
8.2.1 Plasma

Plasma is made up of 90-92% water, 7-8% proteins, 1% inorganic salts and traces of other substances. It is alkaline and light-yellow in color. Sodium chloride and Sodium Bicarbonate are the main inorganic salts present. Other substances include glucose, amino acids, fibrinogen, hormones, urea, etc. Plasma without fibrinogen is called as Serum.

8.2.2 Cellular Components

The cellular components of blood, also known as formed elements, are – Red blood cells (erythrocytes), White blood cells (leucocytes) and Platelets (thrombocytes).

Red Blood Cells (RBCs)



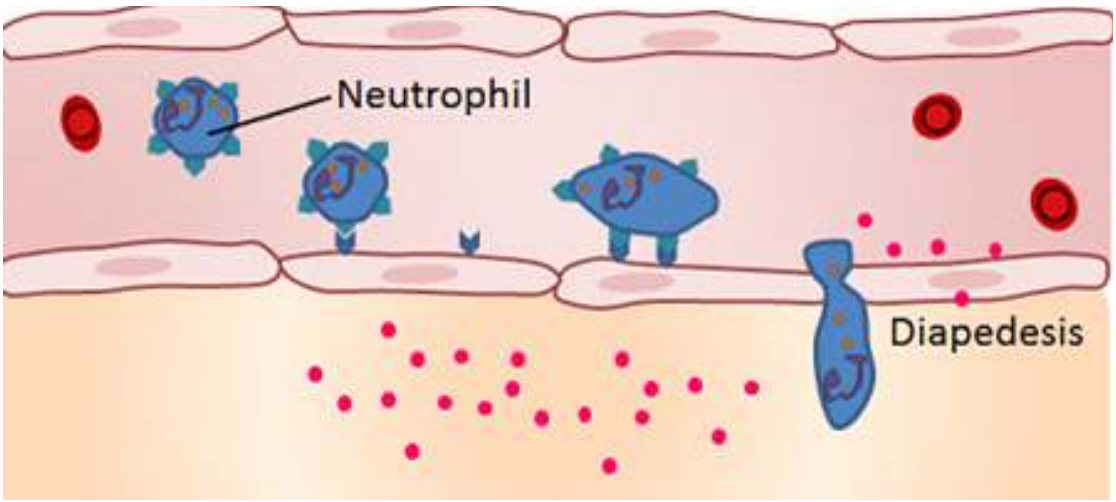
Red Blood Cells

- RBCs are red in color. They have a disc-like biconcave structure. They are thin and flat in the center and thick and rounded at the edges.
- An average Red Blood Cell is 7 micron in diameter.
- The unique structure and small size of the cells provide a large surface area for transport of oxygen.
- The small size also allows the RBCs to travel through small capillaries easily.
- Hemoglobin (Hb) is the essential component of RBCs. It is a respiratory pigment present in the colorless stroma of RBCs.
- Hemoglobin consists of heme (iron containing part) and globin (protein part).
- Hemoglobin combines with oxygen to form an unstable compound called oxyhemoglobin. The oxygen is readily released in the tissues that require it.

- Hemoglobin also combines with carbon dioxide to a small extent to form Carbaminohemoglobin.
- In an embryo, RBCs are produced in liver and spleen.
- In children up to 5 years of age, RBCs are produced in bone marrow of all bones.
- In an adult, RBCs are produced in bone marrow of long bones (ribs, breast bone and ilium of hip girdle).
- When RBCs are produced, they have nuclei. However, as they mature, the nucleus is lost i.e. they become enucleated.
- Mature RBCs lack nucleus, mitochondria and endoplasmic reticulum. This makes them rather more efficient at their work. RBCs have more surface area for carrying more oxygen, they do not use oxygen and glucose for themselves and they have more flexibility in movement through narrow capillaries.
- The average lifespan of a red blood cell is 120 days.
- The old RBCs are destroyed in spleen, liver and bone marrow. The iron part is retained in liver whereas the other parts are excreted as bile pigment (bilirubin).
- An adult male has 5 million RBCs per cubic mm of blood whereas an adult female has 4.5 million of RBCs per cubic mm of blood.
- Around 1% of RBCs are destroyed everyday i.e. 2 million RBCs every second in a normal adult.

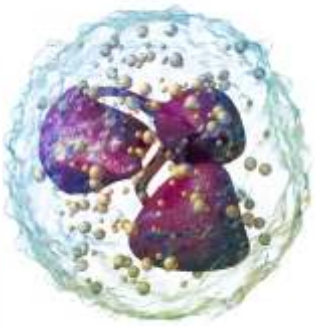
White Blood Cells (WBCs)

- White Blood Cells are nucleated and lack hemoglobin.
- In an adult, the number of WBCs ranges from 4000-8000 per cubic mm of blood.
- WBCs are usually amoeboid and have pseudopodia which they use to squeeze through the walls of narrow capillaries into tissues. This process is known as Diapedesis. It is depicted in the figure below.
- WBCs are produced in red bone marrow, lymph nodes and sometimes in liver and spleen.
- WBCs have an average lifespan of about two weeks.
- The old WBCs are destroyed in the same manner as RBCs.
- Based on their structure and other characteristics, WBCs are distinguished as Granular and Non-granular. Granular WBCs are further classified into three types – Neutrophils, Basophils and Eosinophils. Non-granular WBCs are further divided into two types – Lymphocytes and Monocytes.

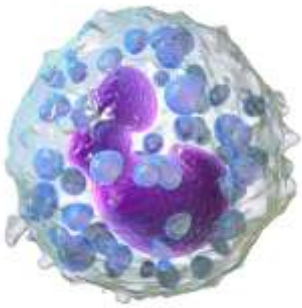


Diapedesis

- Carbon monoxide poisoning occurs when a person is in an environment with very high carbon monoxide concentration. Carbon monoxide on entry in the body, forms a highly stable compound with hemoglobin called as Carboxyhemoglobin (HbCO).
- Formation of HbCO severely decreases the capacity of RBCs of transporting oxygen which may even result in death.

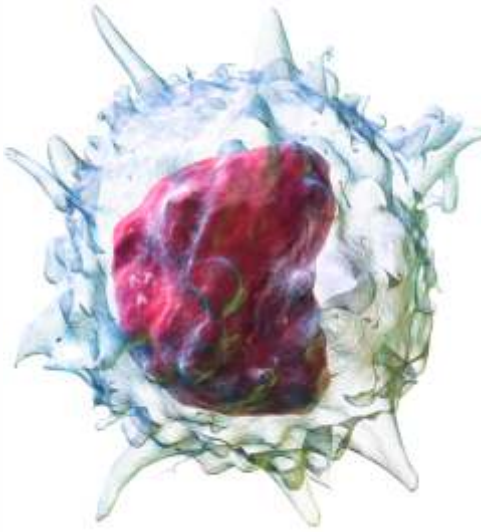


Neutrophils

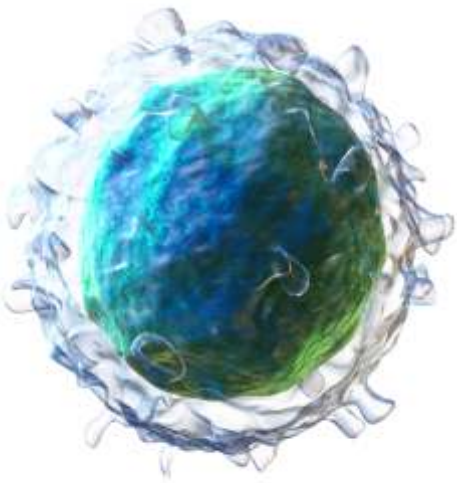


Basophils

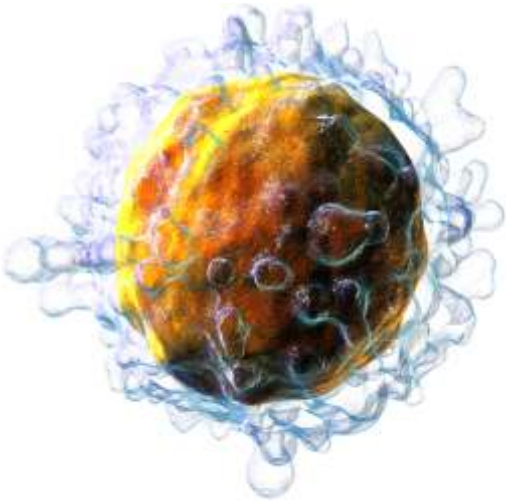
- Neutrophils – They make up 62% of WBCs. Their nucleus is lobed with 3-4 lobes present on average. The cytoplasm is granulated. They can be stained with neutral dyes. They are produced in bone marrow. Their main function is Phagocytosis (engulf bacteria).
- Basophils – They make up 0.4% of WBCs. They have a large nucleus which is indistinctly lobed. The cytoplasm is granulated. The granules can be stained with basic dyes, e.g. methylene blue. They are produced in bone marrow. Their main function is to release chemicals (histamine) at the site of inflammation which dilate blood vessels.
- Eosinophils – They make up 2.3% of WBCs. The number increases during allergic reactions. They have nucleus with two lobes. The cytoplasm is granulated and the granules are large in size. The granules stain dark red with eosin, an acidic dye. They are produced in bone marrow. Their functions include secretion of antitoxins, engulfing bacteria and other functions associated with allergy.
- Lymphocytes – They make up 30% of WBCs. They are smallest in size compared to other WBCs. They have a single large nucleus and agranulated cytoplasm. They are produced in bone marrow and lymph glands. Their main function is to produce antibodies.
- Monocytes – They make up 5.3% of WBCs. The nucleus is large and kidney shaped. They transform into macrophages at the site of infection. They are produced in bone marrow. Their main function is Phagocytosis.



Monocytes



Lymphocytes



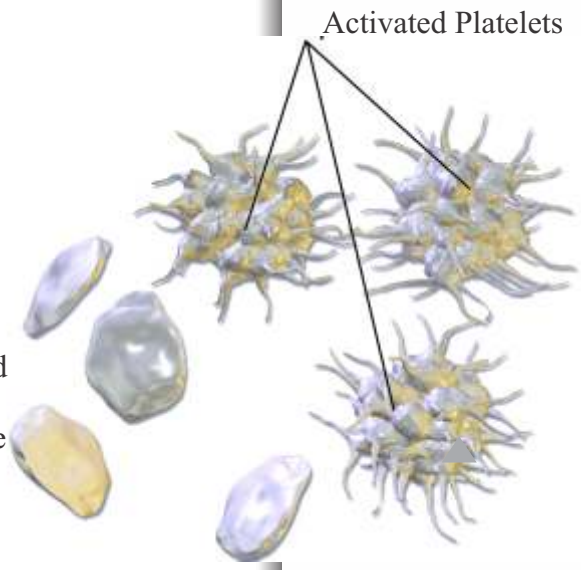
Lymphocytes

- One of the main functions of WBCs is Phagocytosis. It is a process in which particle-like solid foreign substances or microbes are engulfed by the WBCs. An abnormal increase in number of WBCs up to 50000 per cubic mm of blood is an indication of infection.
- Lymphocytes produce antibodies against foreign particles, micro-organisms and toxins released by micro-organisms. The antibodies eliminate microbes and foreign particles from the body. Memory of many antibodies remains even after the infection or disease has been overcome. This makes the person immune to that particular infection or disease. This is the basic principle behind vaccination

- Weakened microbes or toxins of microbes are introduced in the body of a person. This leads to production of antibodies against the introduced substances. The memory of these antibodies will remain so that later in life if the particular microbes enter the body of the person, they will be easily eliminated.
- Heat, Redness, Pain and Swelling are characteristics of inflammation. Inflammation may occur at the site of an injury or at the site of entry of allergens or microbes. WBCs, mainly Neutrophils and Monocytes, reach the site of inflammation through Diapedesis. They destroy the damaged cells and also disease causing microbes by Phagocytosis. Pus may form at the site. Pus contains dead tissue cells and dead WBCs.

Platelets

- Platelets are non-nucleated structures. They are oval or round in shape.
- The number of platelets in an adult ranges from 200,000 to 400,000 per cubic mm of blood.
- In the red bone marrow, giant cells called Megakaryocytes are produced. These cells are budded off in a manner that each resulting structure (platelet) is surrounded by a membrane.
- Their lifespan is from 3 to 5 days. The old platelets are destroyed in spleen.
- The main function of platelets is in the process of clotting. At the site of injury, platelets release a chemical called thrombokinase which initiates the process of clotting.

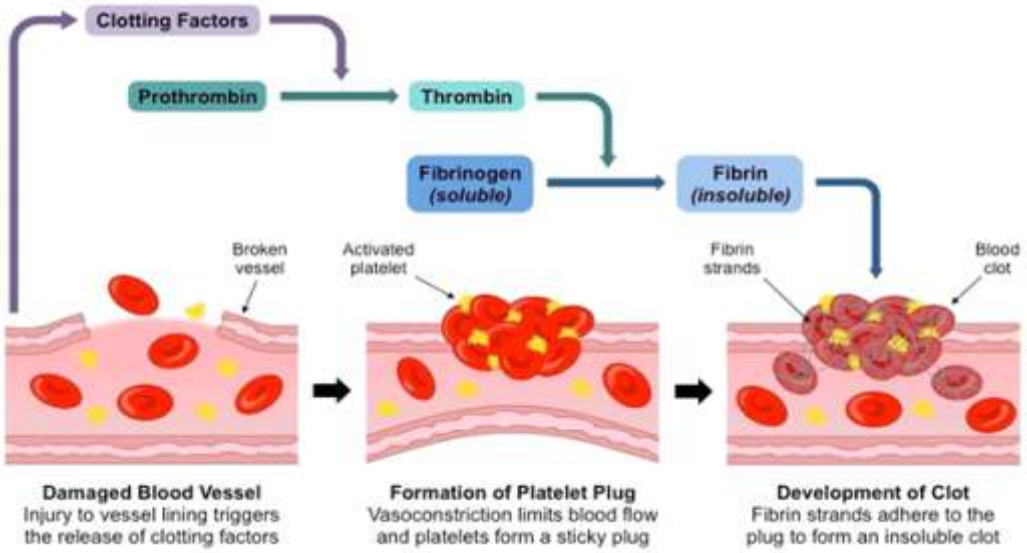


8.3 Blood Clotting

Whenever one gets a cut and it starts bleeding, the bleeding stops after some moments spontaneously. Have you ever wondered how does that happen? Or what exactly happens that the bleeding stops even if the cut is there? We shall find out the answers in this section.

Clotting or Coagulation of blood is the process in which a clot is formed at the site of injury. If this process is not initiated, bleeding would not stop spontaneously. Let us go through the steps of clotting in brief.
At the site of injury, platelets present nearby disintegrate to release a substance called thrombokinase or thromboplastin. It is also known as Stuart factor or Factor X. Prothrombin, an inactive component, is converted to its active form, Thrombin, with the help of calcium ions present in plasma and thrombokinase. Soluble fibrinogen reacts with thrombin in presence of calcium ions to form insoluble fibrin. Fibrin forms microscopic threads which form a network or a mesh at the site of injury. In this mesh, blood cells are trapped. The mesh shrinks and squeezes out plasma which is present in the form of serum. After removal of water component, the solid mass left behind at the site of injury is called as a clot or thrombus. It prevents further bleeding.
We learnt that the platelets are required for the initiation of clotting process. Hence, platelets are essential to this process. If due to some reason, the platelets count in the body decreases, the coagulation process occurs very slowly. This is dangerous as it may lead to hemorrhage. An example of a condition in which platelets count goes significantly below normal range is viral dengue fever.

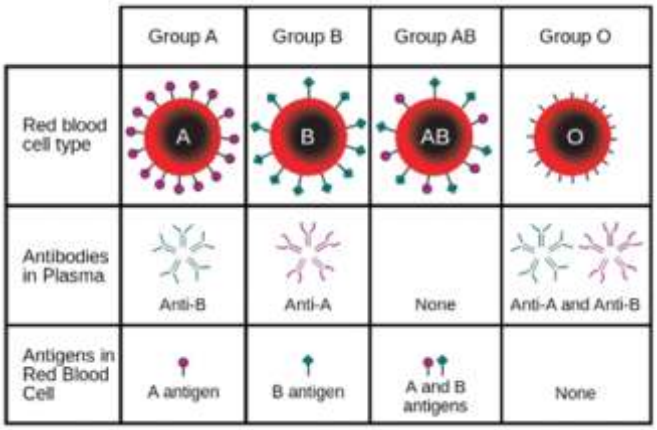
Cascade Of Reactions In Blood Clotting



8.4 Blood Group Systems And Blood Transfusion

The surface of red blood cells consists of protein molecules known as antigens. There are different antigens present on red blood cells in different persons. Whatever antigens are present on RBCs, antibodies complementary to them are present in the plasma of blood.

Blood Groups Based On Abo Blood Grouping System



Blood can be divided into blood groups based on the antigens present on the surface on RBCs. The concept of blood grouping was discovered by Karl Landsteiner. In human beings, there are two main antigens that are found on RBCs – Antigen A and Antigen B. Based on the presence or absence of these antigens, there are four blood groups – A, B, AB and O. They are described in the figure below. Blood grouping system based on presence/absence of antigens A and B is known as ABO Blood Grouping System.

There are other systems of blood grouping available. However, the most essential and widely used systems are ABO system and Rh system.

Blood Transfusion is the process in which blood taken from a donor is transferred in the body of a recipient. This becomes necessary during surgical processes as patients lose quite blood while they are being operated upon. Before blood is transfused, it is essential that the blood groups of donor and recipient match. This is known as blood group compatibility. The compatibility of blood groups in ABO system is tabulated in the figure below.

Blood Group Compatibilty Chart (ABO System)

Recipient	Blood donor			
	O	A	B	AB
O	✓	✗	✗	✗
A	✓	✓	✗	✗
B	✓	✗	✓	✗
AB	✓	✓	✓	✓

In the above table, we can see that a person with O blood type can donate to person with any other blood type viz. A, B, AB and O. Hence, a person with blood type O is called as universal donor. On the other side, a person with AB blood type can receive blood from person with any other blood type viz. A, B, AB, and O. Hence, a person with blood type AB is called as universal recipient. A person with blood type A can receive blood from people having A and O blood types. A person with blood type B can receive blood from people having B and O blood types.

In the Rh system, blood groups are classified based on the presence or absence of D antigen. Blood group of people having D antigen on RBCs is called as Rh positive or Rh+. Blood group in absence of D antigen is called as Rh negative or Rh-. The Rh stands for Rhesus, a monkey in which the antigen was first discovered. Rh system is used along with ABO system to determine compatibility.

Blood of Rh positive donor should not be transfused in Rh negative recipient. If it is done, the body of recipient will develop antibodies against Rh factor in about two weeks. This is known as sensitization (the recipient is now sensitive to Rh factor or D antigen). If a similar transfusion is done for a second time, the antibodies formed after the first transfusion will react with the D antigens thereby destroying the red blood cells with D antigen on their surface. This may lead to death of the person. This process is similar to development of an allergy.

In case of pregnancy, an Rh negative mother may become sensitive to Rh factor if she is carrying an Rh positive child. This will not affect the first Rh positive child. However, if the second child that she is carrying is also Rh positive, then it may become problematic for the fetus. In severe cases, it may lead to abortion or death. Hence, screening for Rh factor during pregnancy is essential.

8.5 Blood Vessels

Blood vessels are tubular structures that extend from heart to all parts of the body. As the name suggests, they are vessels that carry blood. Blood vessels in our body are of three types – Arteries, Veins and Capillaries. Let us understand more about each type of blood vessel.

8.5.1 Arteries

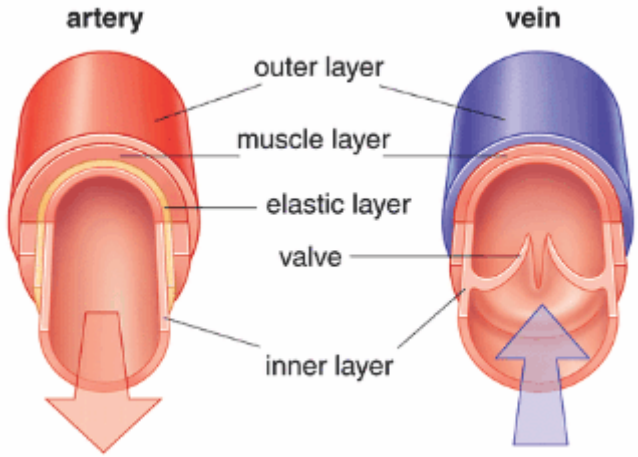
The blood vessels that carry blood away from heart and to any organ in the body are called as Arteries. Arteries have thick muscular walls and narrow lumen. The walls are elastic in nature. There are no valves present within the arteries. They are placed deeper in the body. Within the arteries, blood flows in spurts and with great pressure. The spurts correspond to contractions of ventricles. Except pulmonary artery, all other arteries carry oxygenated blood. Arteries can constrict or dilate for regulating blood flow. Arteries do not collapse even when they are empty. The arteries are progressively branched, decreasing in size. The further branches of smallest artery are called as arterioles. Arterioles can change their diameter manifold. Arterioles further branch into capillaries.

Blood vessels

8.5.2 Veins

The blood vessels that carry blood towards the heart and away from an organ are called as Veins. Veins have thin muscular walls and wider lumen. The walls are non-elastic in nature. There are thin pocket-shaped valves present in the veins. These valves open in the direction of heart and prevent backflow of blood. The blood flows uniformly in the veins. The veins are placed more superficially (near the skin surface). Except pulmonary vein, all other veins carry deoxygenated blood. Veins cannot constrict. Veins collapse when they are empty. The veins progressively unite, increasing in size. The smallest vein arises from unification of venules. Capillaries reunite to form venules.

Comparison Between An Artery And A Vein

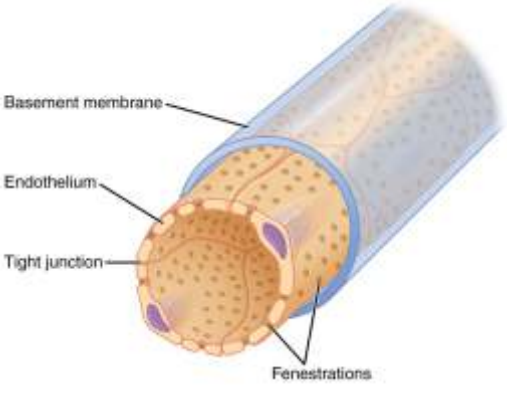


8.5.3 Capillaries

Capillaries are extremely narrow tubes. They are present in a large number. The wall of a capillary consists of single layer of squamous epithelial cells. Capillaries lack muscles.

An artery branches to form arterioles. Arterioles branch to form capillaries. Capillaries reunite, increase in size and gain muscular layer and connective tissue layer to form venules. Venules join to form veins.
Capillaries allow diffusion of oxygen from blood into intercellular fluid and diffusion of carbon dioxide from intercellular fluid into blood. They also allow outward and inward diffusion of substances like glucose, amino acids, urea, hormones, etc. Leucocytes can squeeze out of capillaries by amoeboid movement, if required.

Capillary



The capillaries can regulate blood supply to body parts by undergoing dilation (vasodilation) and constriction (vasoconstriction) as required. An evident example of this is change in color of skin based on outside environment. When we walk outside on a very hot day, blood flow to the face increases and face appears pink. On the other hand, if we take a walk outside on a harsh winter day, the blood flow to the face decreases and face appears very pale or bluish in extreme climate.

8.6 The Circulatory System

Now that we have learnt and understood about blood, its properties, functions and blood group systems, let us learn about how blood is circulated around the entire body with the help of heart and blood vessels.
The Circulatory system comprises of heart and blood vessels – arteries, veins and capillaries.

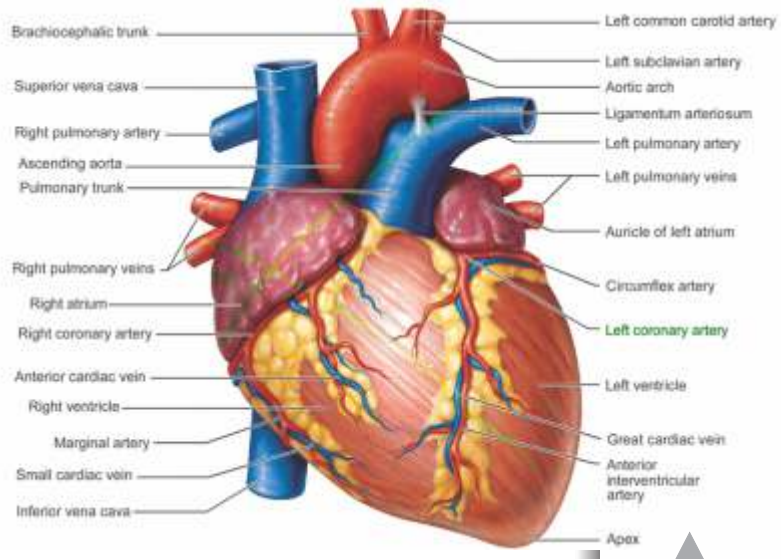
8.6.1 Heart – Location

The heart is present above the diaphragm, between the two lungs. The narrow end of the heart points towards left side. When the heart contracts, the contraction is most powerful at the narrow end. This gives the feeling that heart is situated on the left side.

8.6.2 Heart – Structure

The heart has a rough triangular shape. Its size is approximately equal to the size of one's closed fist – 12cm in length and 9cm in width.

The outer surface of heart is covered by double walled membrane called pericardium. Between the two walls, a lubricating fluid called pericardial fluid is present. The fluid protects the heart from mechanical injuries and reduces friction during contraction and relaxation of heart.
The heart is divided into four chambers – two upper chambers called atria or auricles and two lower chambers called ventricles.
The auricles have thin walls as their function is to receive blood from body and pump it into ventricles. The ventricles have thick muscular walls as their function is to pump blood away from the heart.



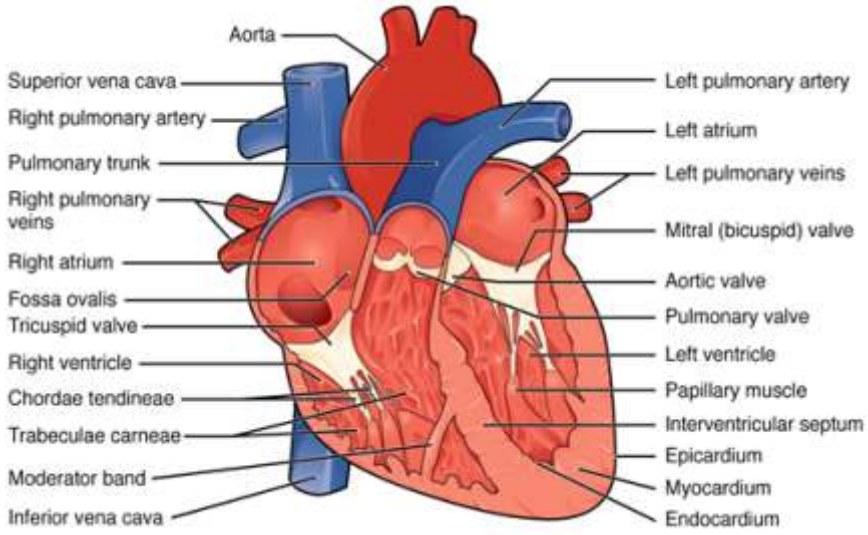
Front View Of Human Heart

Blood flow within the heart and from heart to body is regulated by valves. Valves are flap-like structures that regulate the flow of blood so that it occurs in a single direction. Let us learn about the four main valves of the heart.

- Right atrio-ventricular valve – It is located between right atrium and right ventricle. It is also known as tricuspid valve as it has three triangular leaf-like flaps or cusps. The muscular projections of ventricular walls, papillary muscles, give rise to chordae tendinae which hold the apices of the flaps in position.
- Left atrio-ventricular valve – It is located between left atrium and left ventricle. It has two cusps and is known as bicuspid valve or mitral valve.

- Pulmonary semilunar valves – Three pocket-shaped valves are present at the opening of right ventricle into pulmonary artery.
- Aortic semilunar valves – Three pocket-shaped valves are present at the opening of left ventricle into aorta.

Human Heart – Internal Structure



The anterior and posterior venae cavae are the largest veins that bring blood to the right auricle of the heart. Anterior vena cava or superior vena cava or precaval brings deoxygenated blood from the upper body parts (head, chest and arms). Posterior or inferior vena cava brings deoxygenated blood from lower body parts. Pulmonary vein brings oxygenated blood from lungs to left auricle of the heart. There are four pulmonary veins.

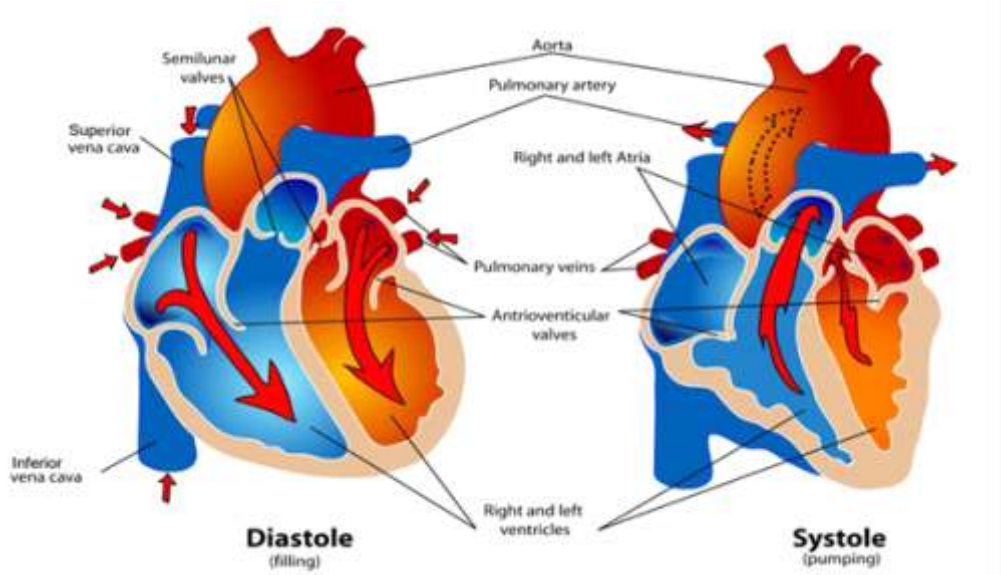
The pulmonary artery carries deoxygenated blood from right ventricle to the lungs. The aorta carries oxygenated blood from left ventricle to all the parts of body. From the aorta, two coronary arteries arise. Coronary arteries supply blood to heart. Coronary veins collect deoxygenated blood from heart and transport it to the right auricle. Myocardial infarction or heart attack happens when a particular area of heart muscles stop functioning (deadening). This happens when there is blockage in a coronary artery or one of its branches. The area of deadening corresponds to the blocked coronary artery. Insufficient blood supply to heart leads to chest pain known as Angina Pectoris.

8.6.3 Blood Circulation

Blood is brought to the right auricle by the venae cavae and to the left auricle by the pulmonary vein. After receiving blood, auricles contract (atrial systole). At the same time, ventricles are empty and in a relaxed state. The blood easily passes from auricles to respective ventricles.

After the blood passes from auricles to ventricles, auricles go in a relaxed state whereas the ventricles contract (ventricular systole). At this point, to prevent back flow of blood to the auricles, the two cuspid valves get tightened so that they remain closed. This is achieved with the help of chordae tendinae that keep the valves in position. So, the blood flows from right ventricle into pulmonary artery and from left ventricle into aorta. The blood flows from ventricles into respective blood vessels without hindrance as the pocket-like valves present at the base of the two blood vessels (pulmonary artery and aorta) face away from the ventricles.

After the ventricles have relaxed, to prevent the backflow of blood from the two blood vessels, the pocket-like valves close the passage between them.



Phases of heart during circulation

8.6.4 Heart Beat

One cardiac cycle (contraction and relaxation of auricles and ventricles) is known as one heart beat. The contraction phase is known as systole and relaxation phase is known as diastole. Each full heart beat lasts for 0.85 seconds.
The cycle begins with contraction of auricles. After blood has flown into ventricles, auricles go in relaxed state. This is followed by contraction of ventricles (ventricular systole). The ventricles relax (ventricular diastole) at the end of ventricular systole. So, now both auricles and ventricles are in relaxed state (joint diastole). This entire sequence makes one cardiac cycle.

Time distribution for the different phases of one cardiac cycle –

Atrial systole	0.15 seconds
Ventricular systole	0.30 seconds
All chambers in relaxed state	0.40 seconds

Heart beat can be counted indirectly by counting the pulse. When ventricles contract and blood flows through the arteries, the walls of arteries expand. This expansion of arteries can be felt by gently pressing fingers on a superficial artery, e.g. radial artery of the wrist. The alternate expansion and contraction of arterial walls is known as Pulse. Increase and decrease in pulse rate can be correlated to increase or decrease in heart beat rate respectively.
Heart beats can be heard by placing an instrument called Stethoscope over the chest region where heart is located. The sounds that one hears are “LUBB” quickly
followed by “DUP” which is followed by a gap. Closing of atrio-ventricular valves
at the end of ventricular systole gives rise to the sound “LUBB”. Closing of semi-lunar valves at the beginning of ventricular diastole gives rise to the sound “DUB”.

Heart beat rate (number of heart beats in unit time) differs not only between different species but also among individuals of same species. Heart beat rate also varies based on size of the organism – smaller the body, faster the heart rate. In the growing stages of an individual, the rate of growth is higher and so metabolism is also high. The faster heart rate helps in balancing supply and removal of metabolic substances. Also, if the body is small, body heat is lost at a faster rate. The faster heart rate helps in faster distribution of body heat. Heart beat rates of different individuals of a species and some of the different species are given in the table below.

A Newborn baby	140
Adult men	64-72
Adult women	72-80
Rat	250
Horse	40

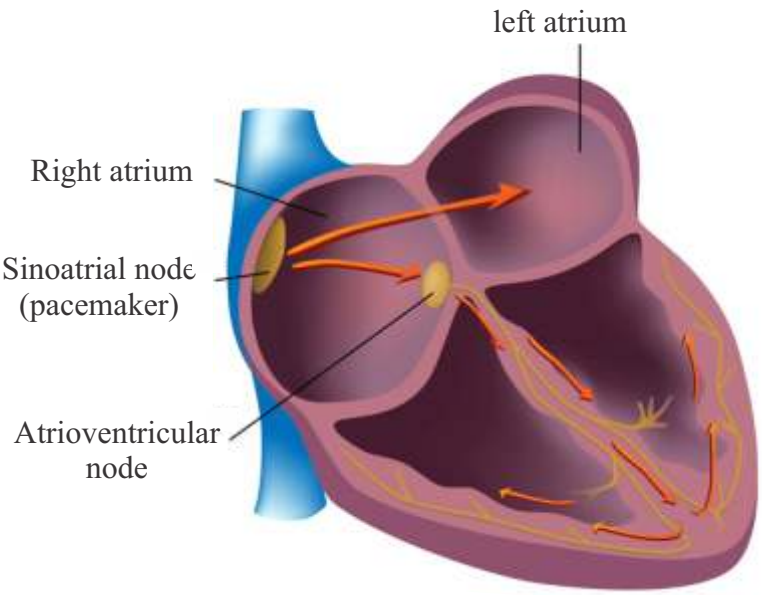
8.6.5 Blood Pressure

The blood that flows through the arteries exerts pressure on arterial walls. This pressure is called as Blood pressure. There are two limits to this pressure. The pressure of blood flow following ventricular systole is termed as systolic pressure. It forms the upper limit. After ventricular systole, when ventricles go into relaxing phase, the pressure of blood flow is termed as diastolic pressure. It forms the lower limit of blood pressure. The normal range for systolic pressure in an adult human being is 100-140 mm of Hg and for diastolic pressure is 60-80 mm of Hg. High blood pressure or Hypertension is the condition in which blood pressure increases above 140/90.

8.6.6 Pacemaker

We now know that heart undergoes alternate contractions and relaxations at a particular pace. So, what triggers the contractions of heart? The contractions are triggered by electrical impulses. These impulses are generated by specialized cells found in heart. The impulses are propagated by a particular part of heart known as sino-atrial node (SAN). SAN helps in regulating the heart rate and is therefore called as Pacemaker of heart. It is located on the walls of right auricle.

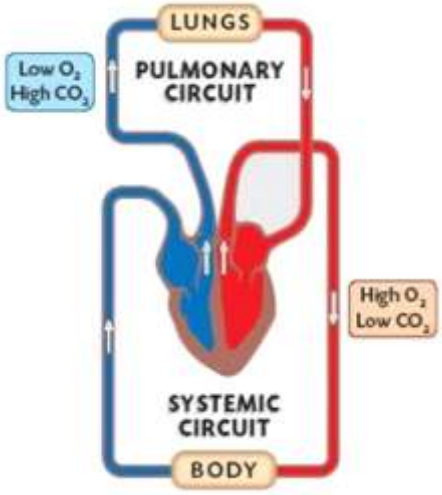
A secondary pacemaker called atrio-ventricular node or AVN is present near the interauricular septum. From AVN arises a bundle of fibers called 'Bundle of HIS' which extends to the interventricular septum. Purkinje fibers are branches of fibers that run along the walls of ventricles. The nodes and fibers together form electrical conduction system of heart. If ever something goes wrong with the pacemaker of heart, the heart rate may become inconsistent. The solution to this problem is placement of an artificial pacemaker in the body of the person.



Electrical Conduction System Of Heart

8.7 Pulmonary And Systemic Circulation

One full cycle of blood circulation is divided into two parts – Pulmonary Circulation and Systemic Circulation. Hence, blood circulation in our body is also known as Double circulation.

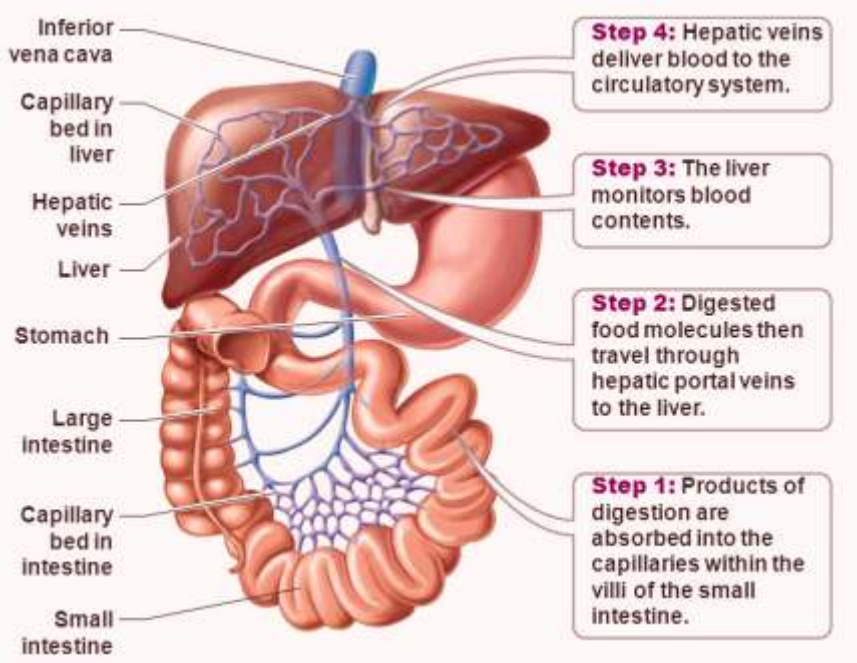


Pulmonary circulation involves circulation of blood between heart and lungs. After the right ventricle receives deoxygenated blood from the right auricle, the blood is transported to lungs via pulmonary artery. Pulmonary artery divides into two branches. Each lung receives blood from one branch of pulmonary artery. After oxygenation of blood, it is carried to the left auricle of heart by the pulmonary veins. Systemic circulation involves circulation of blood between heart and various parts of body. After the left ventricle receives oxygenated blood from the left auricle, it is transported to various parts of body via aorta. The aorta progressively branches and the branches carry blood to tissues and cells of the body. From various parts of body, veins collect deoxygenated blood and it is brought to the right auricle by superior and inferior venae cavae.

8.8 Hepatic portal system

A Portal system is one which begins with capillaries and ends into capillaries. One such system in our body is the Hepatic portal system. The capillaries carrying blood from cells of stomach and intestines combine to form veins. These veins do not bring blood directly to the posterior vena cava. Rather, these veins combine to form one hepatic portal vein which enters the liver. In the liver, the hepatic portal vein, uncharacteristically, branches out into capillaries. These capillaries then reunite to form the hepatic vein.

This system is required for transport of nutrients (absorbed in blood) from digestive tract to the liver. Liver regulates the amount of nutrients flowing in blood circulation. It also detoxifies the nutrients in case of presence of potentially harmful substances.



8.9 Lymphatic System

Let us now study about the lymphatic system which works in parallel to the primary circulatory system.

8.9.1 Tissue Fluid

The fluid that leaks out from the capillaries in spaces between the cells is known as Tissue fluid or Intercellular fluid. It consists of mainly leucocytes and blood plasma. Oxygen molecules diffuse through this fluid and are absorbed by the cells. Along with oxygen, other substances carried by the blood in capillaries also diffuse toward the cells. In turn, cells give out carbon dioxide and other wastes which are taken up by the tissue fluid.

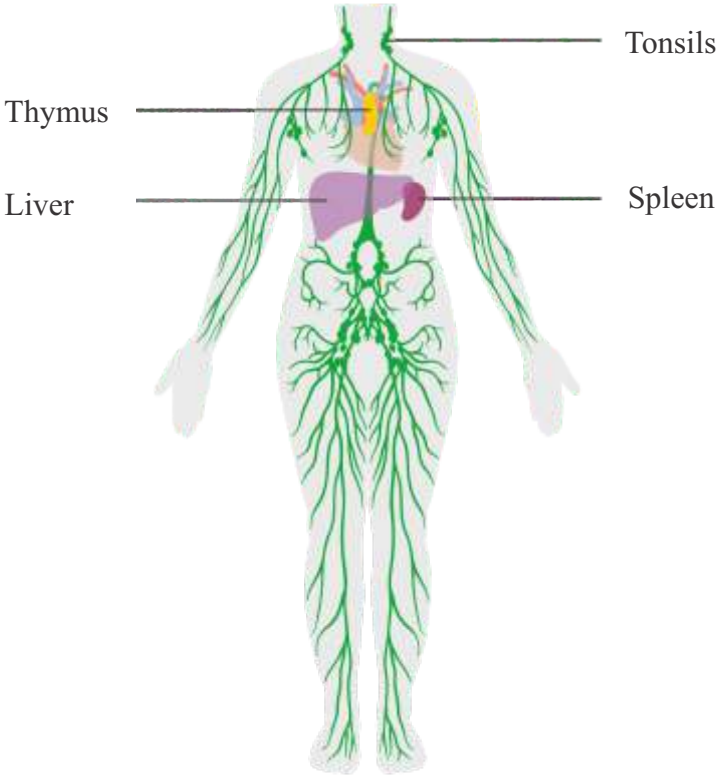
8.9.2 Lymph

Lymph is the part of tissue fluid that is not reabsorbed in the blood vessels. Rather, lymph flows through another type of channels or vessels called as Lymph vessels or Lymphatics. The tissue fluid or lymph that flows through the lymph vessels is made up of 94% water and 6% of solids including antibodies, carbohydrates, fats, proteins, enzymes, etc. It also consists of leucocytes, from among them mostly lymphocytes.

The flow of lymph through its channels is made possible by contraction of muscles surrounding the channels. Lymph is carried and drained in the lymph nodes. From the lymph nodes, another set of lymph vessels or lymph channels arises which carry the lymph to the anterior veins, close to their entry in the right auricle. And this is how lymph is circulated.

8.9.3 Functions Of Lymph

- Blood cannot reach the most interior parts of body. Those parts are supplied by oxygen and nutrients by the lymph.
- Lymphatics present near the villi of intestine, known as lacteals, absorb fat molecules from the intestine.
- The tissue fluid not reabsorbed in the blood vessels is drained as lymph into lymph vessels and ultimately reaches to the heart.
- An important function of lymphatic system is defense. The major cellular parts of lymph are lymphocytes. They provide protection to the cells and tissues from harmful bacteria and other foreign agents.



Lymphatic system

8.9.4 Spleen

In our body, there are organs which contain lymphoid tissues known as lymphatic organs. One such organ is spleen. Spleen is reddish brown in color and located behind the stomach, above the left kidney.
Spleen is the site of production of red blood cells in embryo. Spleen later becomes one of the sites of lymphocyte production. It is also the site where old and worn-out RBCs are destroyed. Spleen also stores blood, acting as a blood reservoir. The stored blood is released in case of hemorrhage, physical or emotional stress or carbon monoxide poisoning.

Summary

- Blood is the primary circulating fluid of our body.
- The cellular components of blood, also known as formed elements, are – Red blood cells (erythrocytes), White blood cells (leucocytes) and Platelets (thrombocytes).
- Hemoglobin combines with oxygen to form an unstable compound called oxyhemoglobin. The oxygen is readily released in the tissues that require it.
- One of the main functions of WBCs is Phagocytosis. It is a process in which particle-like solid foreign substances or microbes are engulfed by the WBCs.
- Clotting or Coagulation of blood is the process in which a clot is formed at the site of injury.
- The surface of red blood cells consists of protein molecules known as antigens.
- Based on the presence or absence of Antigen A and Antigen B, there are four blood groups – A, B, AB and O.
- A person with blood type O is called as universal donor.
- A person with blood type AB is called as universal recipient.
- In the Rh system, blood groups are classified based on the presence or absence of D antigen.
- Blood vessels in our body are of three types – Arteries, Veins and Capillaries.
- The blood vessels that carry blood towards the heart and away from an organ are called as Veins.

Summary

- Capillaries allow diffusion of oxygen from blood into intercellular fluid and diffusion of carbon dioxide from intercellular fluid into blood.
- The heart is divided into four chambers – two upper chambers called atria or auricles and two lower chambers called ventricles.
- One cardiac cycle (contraction and relaxation of auricles and ventricles) is known as one heart beat.
- The contraction phase is known as systole and relaxation phase is known as diastole.
- Each full heart beat lasts for 0.85 seconds.
- The alternate expansion and contraction of arterial walls is known as Pulse.
- Heart beat can be counted indirectly by counting the pulse.
- Heart beat rate varies based on size of the organism – smaller the body, faster the heart rate.
- The blood that flows through the arteries exerts pressure on arterial walls. This pressure is called as Blood pressure.
- The normal range for systolic pressure in an adult human being is 100-140 mm of Hg and for diastolic pressure is 60-80 mm of Hg.
- Sino-atrial node (SAN) helps in regulating the heart rate and is therefore called as Pacemaker of heart.
- One full cycle of blood circulation is divided into two parts – Pulmonary Circulation and Systemic Circulation.

Summary

- A Portal system is one which begins with capillaries and ends into capillaries. One such system in our body is the Hepatic portal system.
- The fluid that leaks out from the capillaries in spaces between the cells is known as Tissue fluid or Intercellular fluid.
- An important function of lymphatic system is defense.
- Spleen is a lymphatic organ.